

CeC Electron Gun Tests and Final System Commissioning Plan

Outline

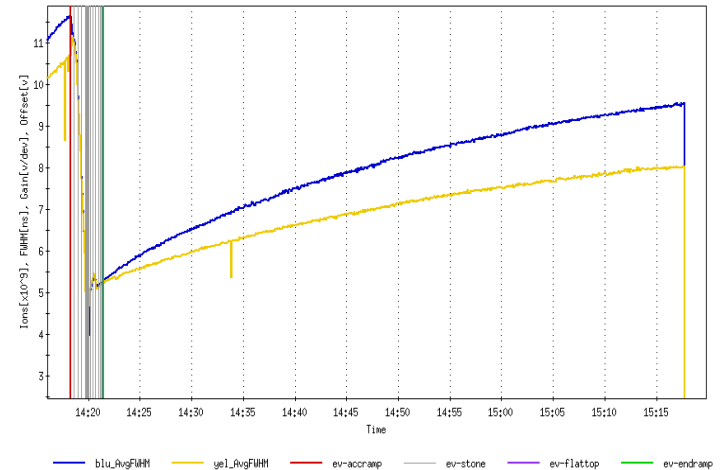
- Studies of the ion beam
- Tests of the CeC PoP gun
- Commissioning of the CeC PoP injector
- Commissioning of the full system
- Cooling observation

CeC PoP RHIC Ramp Development

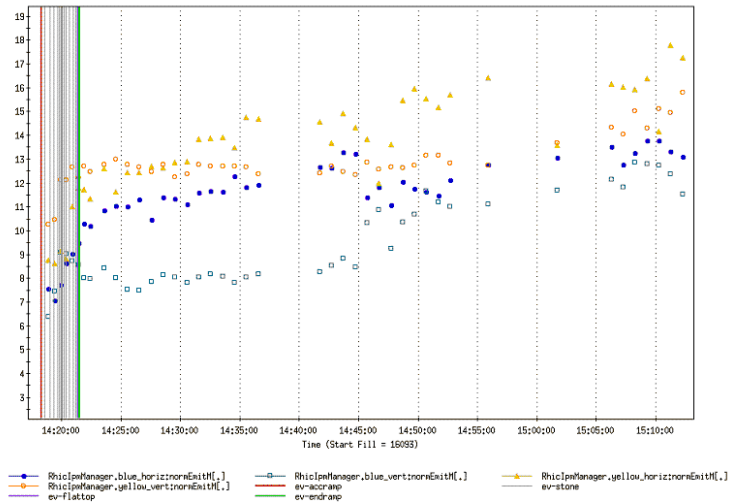
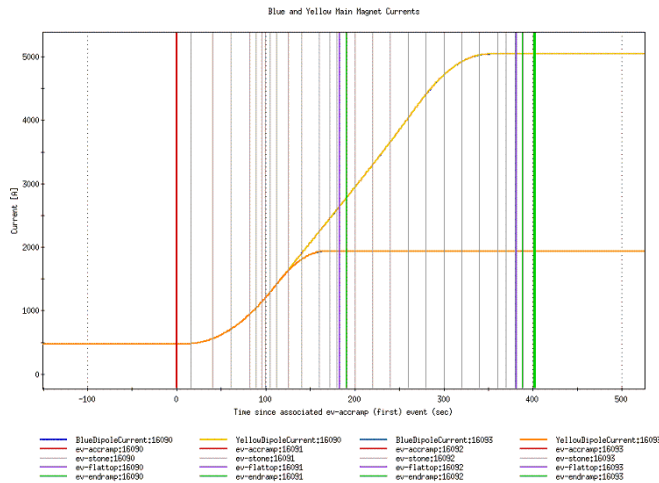
Ramp : APEX on RUN 11: 2pm-4pm, June 20th ,
2011 Fill: 16093

Bunch length

- ramp from injection to 40 GeV/u was developed
- 95% emittance increased from 10 to 15 mm mrad over one hour
- bunch length grew from 5 to 8 nsec r.m.s.
- lost about 5% particle over one hour

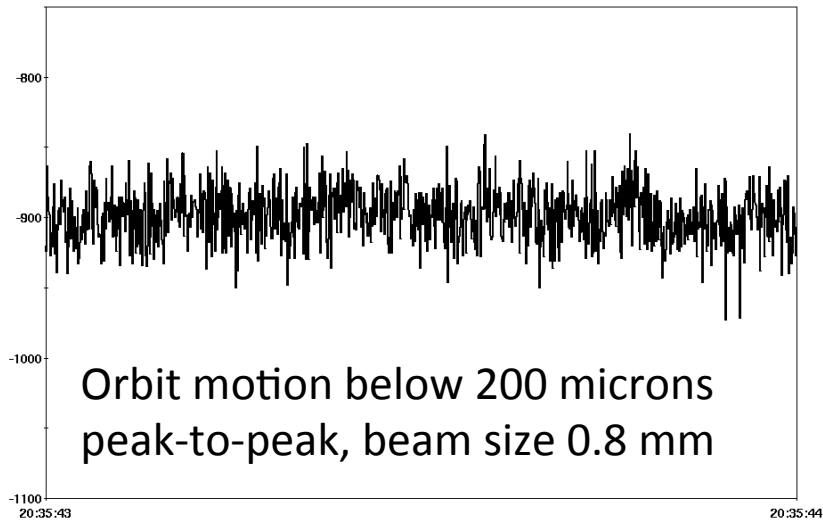


Emittance growth at 40 GeV



magnets currents

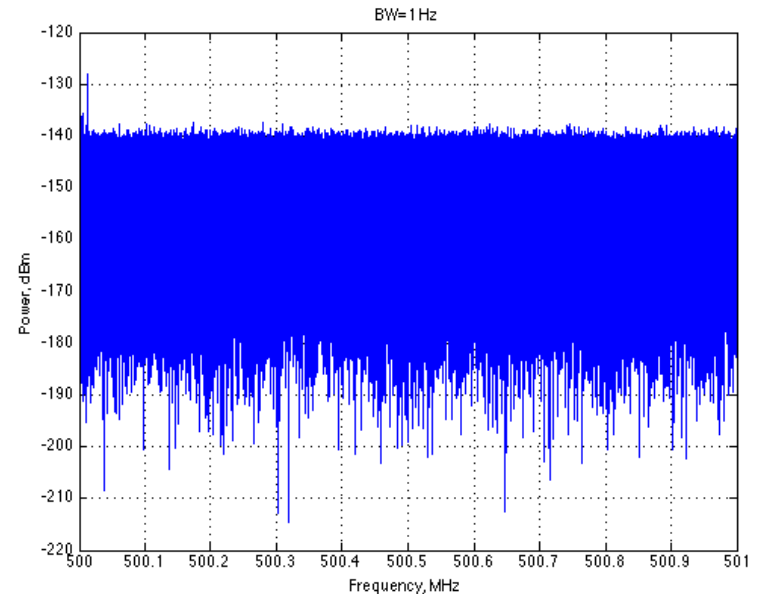
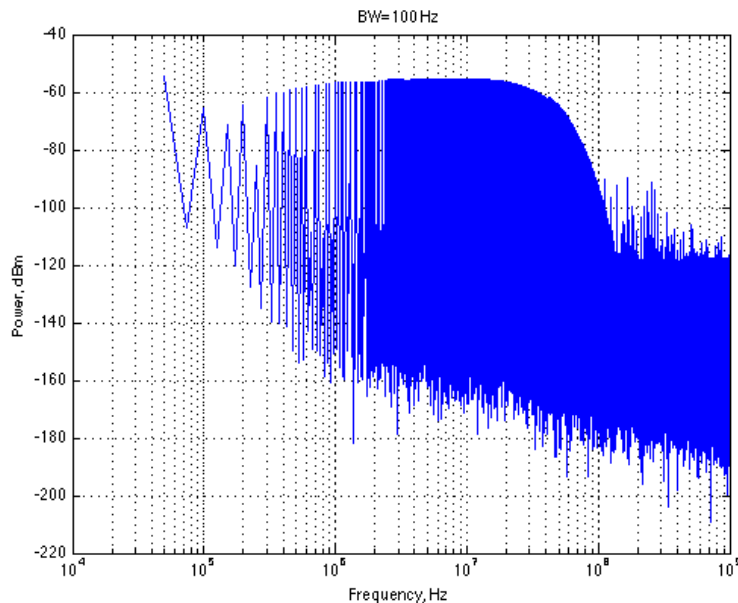
Ion Beam Parameters Characterization



Time (Start Fill = 16936)
bpm10Hz,2a-gofb1,y12-bh1:posRaw[L,]

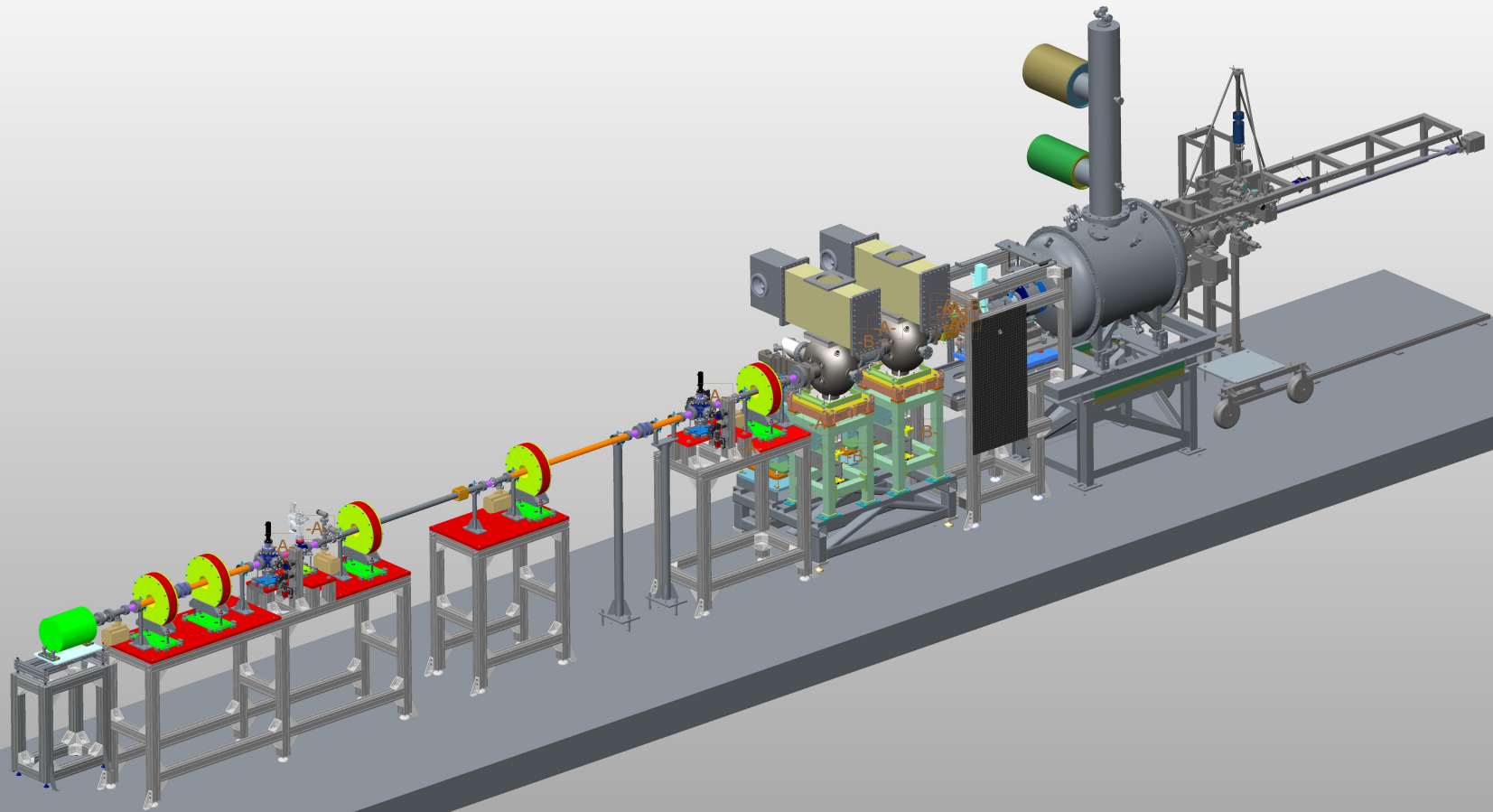


We need jitter below 30 psec



Noise floor is 80 dB below the signal at revolution frequency.

Layout of Presently Installed Equipment

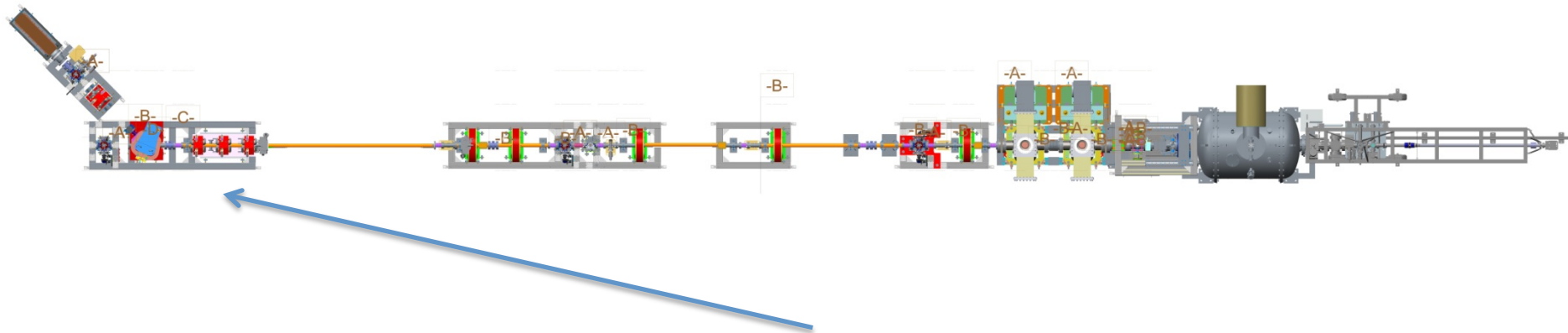


X.X+0.1
X.XX+0.01
X.XXX+0.001
ANG.+0.5

Test Activities before Run15

Activity	Status
Certify personnel protection system (PASS)	✓
Test Machine Protection System (vacuum, utilities, cryogenics)	✓
Test 500 MHz cavities	✓
Commission 4K cryogenic system	✓
Test 112 MHz gun	in progress
Test beam diagnostics (ICT, BCM, profile monitors, Faraday cup)	in progress
Test magnet system	in progress
Test cathode exchange mechanism	photocathodes are loaded, problem was found
Condition 112 MHz cavity to full voltage and acceptable vacuum levels	1.8 MV reached
Estimate “storage” lifetime of the photocathode and cathode quantum efficiency	in progress
Test synchronization and timing system	in progress

CeC PoP Layout for Run15

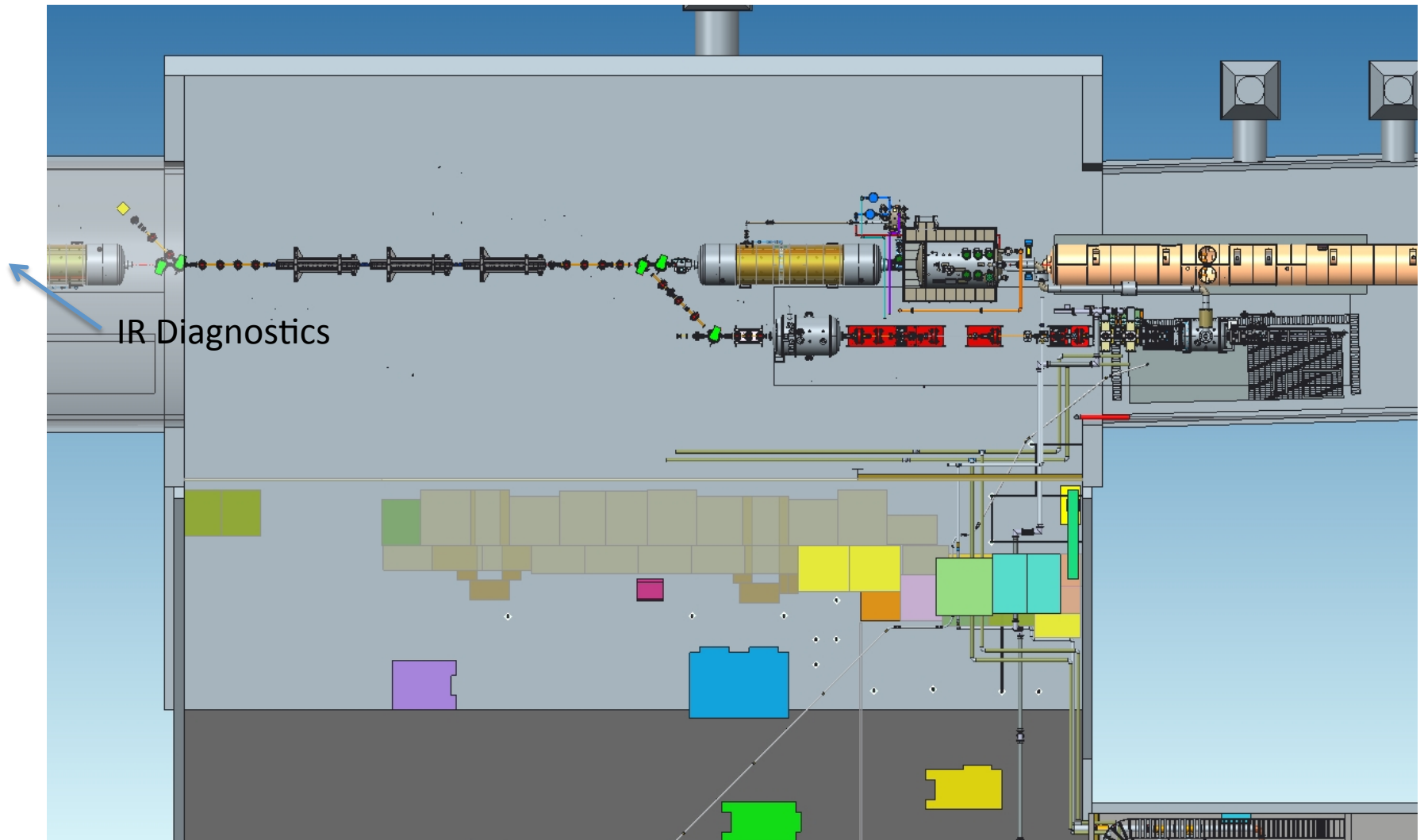


- A spool piece will be installed in place of 704 MHz cavity
- Quadrupole triplet and the first dipole will be installed
- Low power beam dump will be moved after the dipole
- High power dump will be installed preceded with a quadrupole, profile monitor, BPM, and the second ICT

Injector Commissioning during Run15

- Main goal: deliver 2 MeV 2 nC 78 kHz electron beam to the dump. Normalized emittance $\leq 5 \text{ mm}\cdot\text{mrad}$
- Train personnel to operate CeC PoP system
- Measure beam parameters
- Commission low energy beam diagnostics
- Measure QE and lifetime of the Cs_2Sb photocathode
- Finalize cathode replacement procedure
- Commission high repetition rate MPS (add beam position, transmission)
- Commission timing and synchronization system

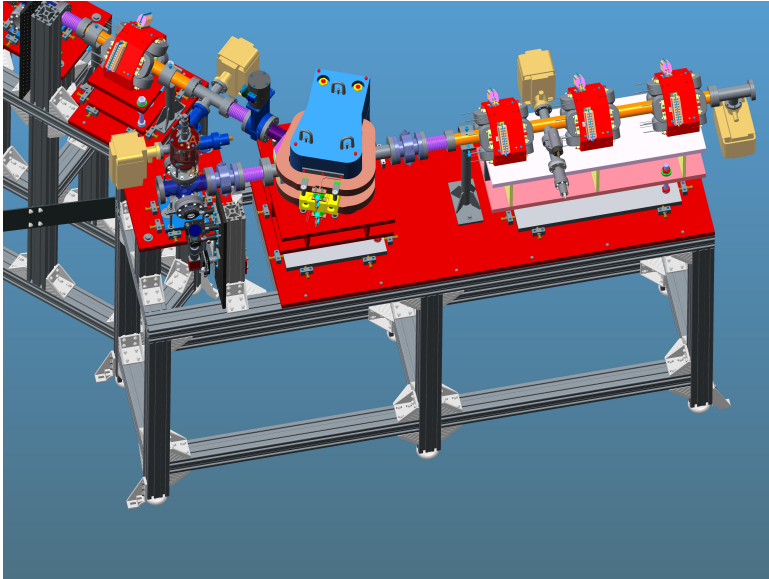
Final CeC PoP Layout



Final CeC PoP System Commissioning

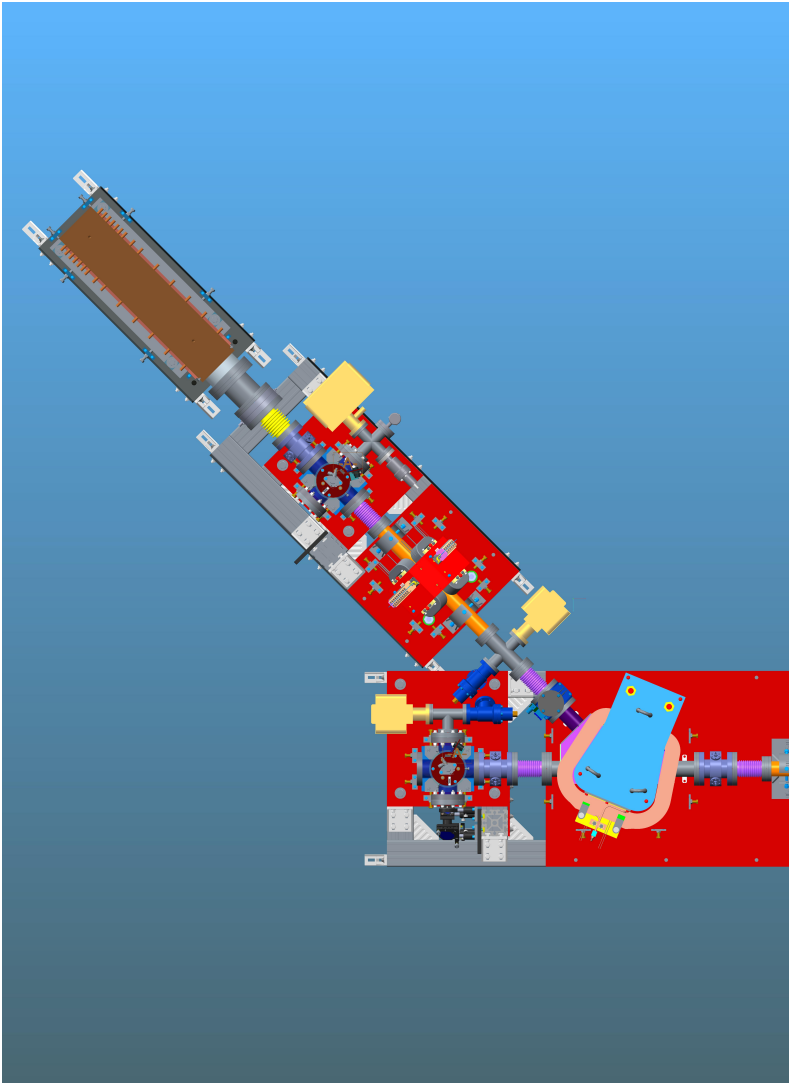
- Main goal: deliver 22 MeV 2 nC 78 kHz electron beam to the dump, relative energy spread $\sigma_E/E \leq 10^{-3}$
- Measure beam parameters
 - emittance 15% accuracy (50 microns resolution)
 - energy spread 10^{-4} accuracy (0.5 m dispersion)
 - charge 1% accuracy
 - pulse length 0.2 psec accuracy (for 5° off crest acceleration)
- Commission all beam diagnostics
- Commission IR diagnostics
- Commission full scale MPS
- Commission timing and synchronization system (704 MHz RF is added)

Emittance Measurement



- Emittance of the low energy beam will be measured with pepper pot (set of slits)
- High energy beam will be done with quadrupole scan utilizing three quadrupoles after the 704 MHz cavity and dipole switched off

Pulse length and Energy Spread Measurement



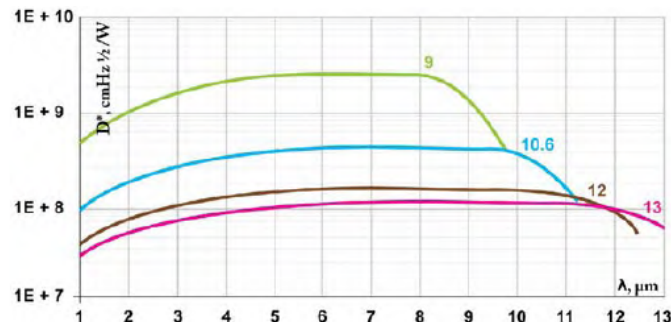
- Both parameters will be measured in the dogleg section where dispersion is not zero
- Energy spread will be found from the beam size with known emittance contribution
- Pulse length will be found from the off crest beam acceleration and corresponding increase of the beam size

Transverse Alignment of Ion and Electron Beams

- First we will establish the offset between ion and electron BPMs when only electron beam is present
- We will measure ion beam position
- Then we adjust electron beam with accordance of previously measured offsets

IR Diagnostics

- Wavelength 13 microns
- Power level of spontaneous radiation for expected 100 μA e-beam is 50 nW
- Power of FEL is up to 1 W
- Low power photoconductive detector PCI-3TE-13
 - 2 – 14 μm spectral range
 - Detectivity $\geq 6 \times 10^7 \text{ cmHz}^{1/2}/\text{W}$ (NEP 1.7 nW in 1 Hz BW)
- Thermal power sensor 3A by Ophir
 - flat spectral response 0.19-20 microns
 - power range 60 μW – 3 W
 - noise level 2 μW



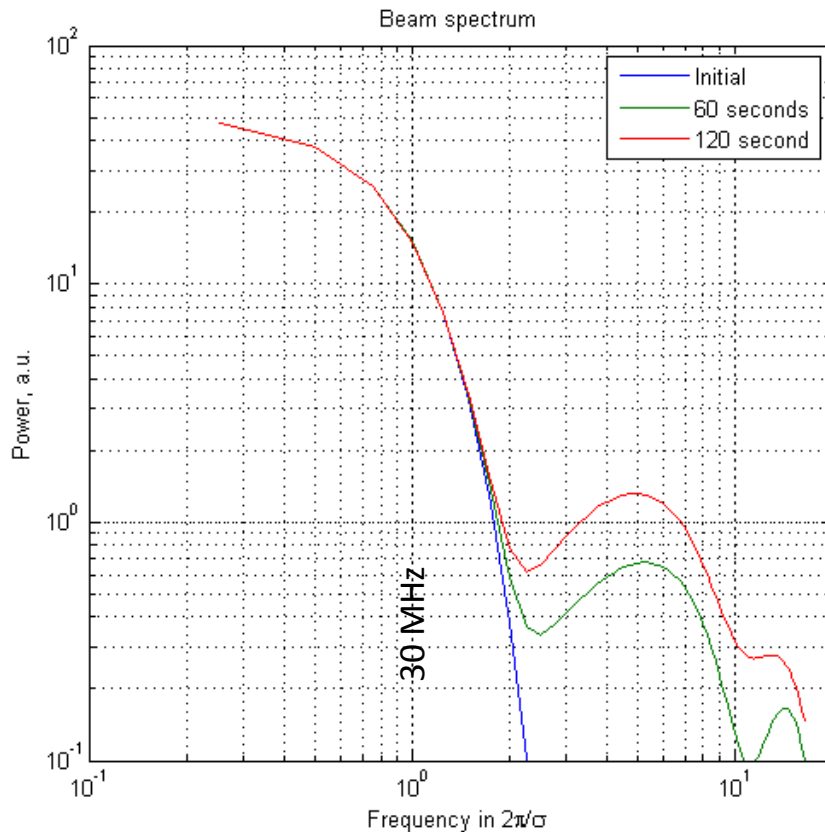
3A / 3A-P / 3A-P-THz



Energy Matching of Ion and Electron Beam

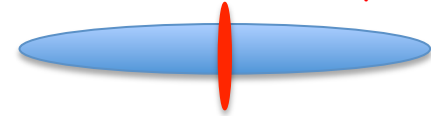
- Energy matching will be performed using IR detector after transverse alignment is complete
- When energies are matched the electrons are grouped around ions thus effectively increasing shot noise and power of spontaneous emission from helical undulators (gain of the FEL structure can be suppressed by lowering peak electron current)
- Another way is to measure the recombination rate

Anticipated Beam Dynamics

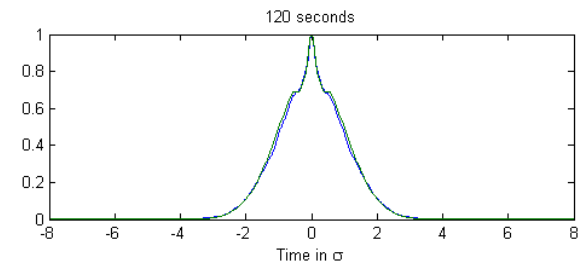
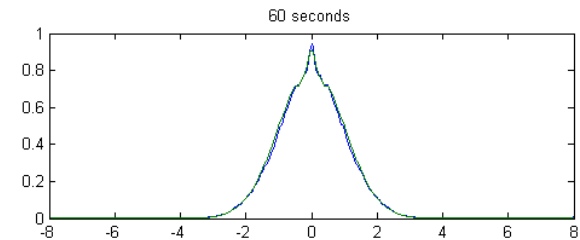
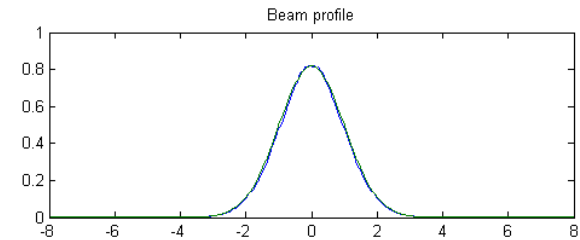


r.m.s. length of the cooled part 80-120 ps. The cooling effects can be observed with oscilloscope 2 GHz or more bandwidth or spectrum analyzer with similar upper frequency

Electron bunch - 20 psec



Ion bunch - 5 nsec



Modeling of cooling is performed with betacool by A. Fedotov

For demonstration only: detailed simulations will be done using complete CeC package

Cooling Observation of Ion Beam

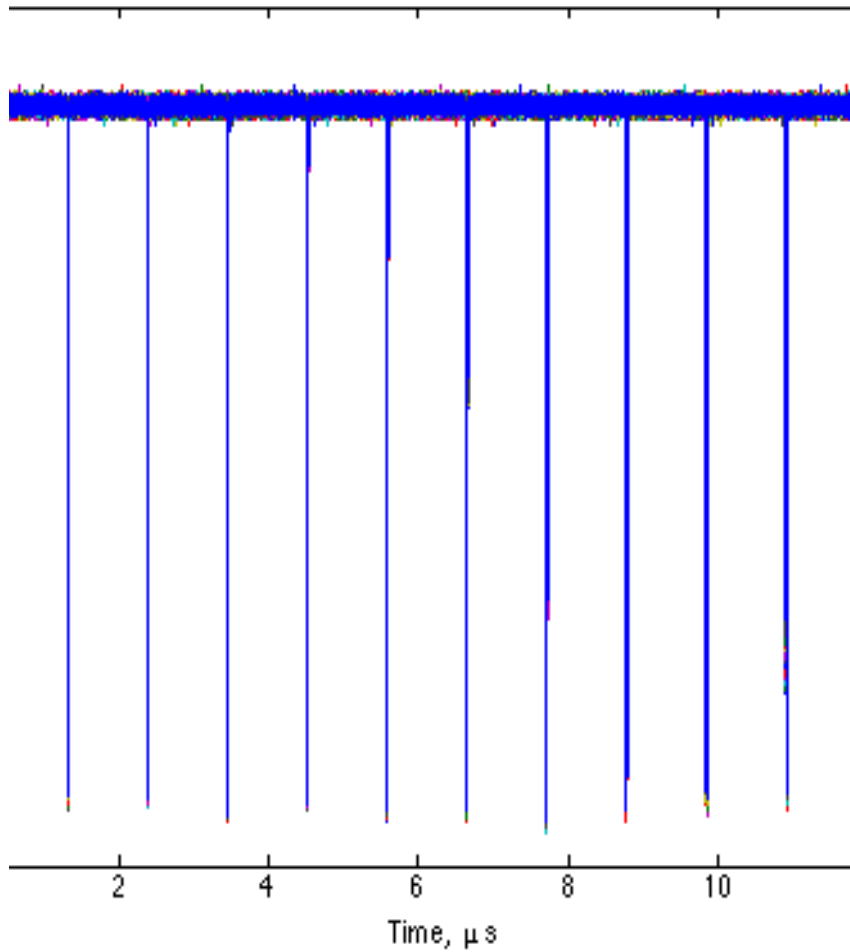
- We will observe spectrum of the wall current monitor in the high frequency range (500-1000 MHz)
- The final observation will be done with observation of the ion bunch shape change
- After successful cooling of the ion bunch core we will attempt to cool the whole bunch by longitudinal scan of the electron bunch (“painting”)

Conclusions

- We have performed analysis of the RHIC beam parameters for CeC PoP experiment and found them acceptable
- We have started commissioning of the equipment installed so far
- To reduce risk we will commission the injector for CeC PoP experiment during Run 15
- We are developing diagnostics equipment for which can improve performance (dual beam BPMs and beam charge monitors)
- Final commissioning and tests will be performed during Run 16

Beam Profile

77 turns overlapped, $F_{sv} = 78.193$ KHz



77 turns overlapped, $F_{sv} = 78.19294$ kHz, zoom first bunch

